5 Monitoring California's Conservation Actions

Monitoring and Adaptive Management

Natural communities, ecosystems, species population dynamics, and the effects of stressors on the environment are inherently complex. Wildlife and resource managers often are called upon to implement conservation strategies or actions based upon limited scientific information and with considerable uncertainties. Adaptive management is a key element in implementing effective conservation programs. Adaptive management combines data from monitoring species and natural systems with new information from management and targeted studies to continually assess the effectiveness of, adjust, and improve conservation actions.

Some conservation actions recommended in this Wildlife Action Plan may be assessed adequately simply by monitoring a few environmental variables. At the other extreme, a regional multispecies conservation effort requires a major long-term comprehensive monitoring program. The steps and considerations needed to design a monitoring program in an adaptive management context are summarized below. This information is a guide to designing a program to measure the success of the conservation actions of this wildlife plan and will be useful to consider, whether developing a major regional conservation plan or a very limited conservation project.

Designing a Monitoring Program to Support Adaptive Management

All of the information in this section regarding monitoring and adaptive management is adapted from a guidance document developed collaboratively by the California Department of Fish and Game, the U.S. Geological Survey, and the U.S. Fish and Wildlife Service. For a full discussion of monitoring for effectiveness of regional conservation planning, see the entire document: Atkinson, A.J., P.C. Trenham, R.N. Fisher, S.A. Hathaway, B.S. Johnson, S.G. Torres, and Y.C. Moore. 2004. Designing monitoring programs in an adaptive management context for regional multiple species conservation plans. U.S. Geological Survey Technical Report. USGS Western Ecological Research Center, Sacramento, Calif. 69 pages. (Available at http://www.dfg.ca.gov/nccp/pups/monframewk10-04.pdf)

Monitoring species, habitat, and natural communities to assess the success of conservation efforts involves, at a minimum, effectiveness monitoring and targeted studies.

Effectiveness monitoring evaluates the success of the conservation action or conservation plan in meeting its stated biological objectives (Noss and Cooperrider 1994). Typical effectiveness monitoring measures:

- Status and trends of resources (e.g., quantitative data on priority species, biodiversity, vegetative structure)
- Status and trends of known pressures (e.g., invasive species, contaminants, disturbance)
- Effects of management actions on resources and known pressures (e.g., density of invasive plants measured before and then 1 to 5 years after herbicide treatment)

Targeted studies are a special subset of effectiveness monitoring. Targeted studies increase the effectiveness of monitoring and management by improving knowledge about the ecological system and about management techniques. Targeted studies are short-term studies rather than long-term monitoring; they typically include resolving critical uncertainties and improving knowledge of natural systems under management and applying experimental management treatments.

Adaptive management openly acknowledges our uncertainty about how ecological systems function and how they respond to management actions. Adaptive management involves monitoring, targeted studies, and applying management activities as experimental treatments. The results feed back into decision-making, reducing uncertainty and improving the effectiveness of the program through time (Walters 1986; Noss et al. 1997; Nyberg 1998; Wilhere 2002).

Foundational scientific principles and the best available empirical information inform both the conservation goals and the strategy for implementing conservation plans. Ideally, this process includes the following steps: identify the conservation goals, create a simple conceptual model of how the ecosystem functions or of a species life history (such models can also help to define the goals), and use the conceptual model(s) to identify a conservation strategy, followed by an implementation approach involving management activities and monitoring.

Conceptual models summarize our current understanding of ecosystem or community function or species life history, clarifying likely responses to management actions and pressures (i.e., stressors, causes of change). Problem-focused conceptual models that link program objectives to causes of change and to management activities are particularly helpful to adaptive management and provide a key bridge from the conservation strategy to management and monitoring.

Assumptions upon which the proposed conservation strategy and management program are based can be tested through monitoring and with targeted studies and experimental management. Monitoring, which measures ecosystem condition and responses of the ecosystem to both intentional (management actions) and natural perturbations, is a critical piece of the adaptive management feedback loop. Ideally, monitoring can identify problems early, so that corrective management action can be taken as soon as it is needed. Conversely, targeted studies (at small spatial scales or in pilot studies) may be more appropriately used to resolve critical questions regarding ecosystem functioning or management applications.

The results from monitoring and targeted studies are evaluated and used to update goals and conceptual models and to revise the conservation strategy and implementation (management) program, as well as the monitoring methodology and even foundational scientific knowledge.

Steps to Create a Monitoring Program

Below are specific guidelines and recommendations for constructing a functional and scientifically defensible monitoring program. There is no one best approach for managing and monitoring any system; however, following these steps will produce a monitoring program based on the best available science. Although originally tailored to monitoring programs that fulfill specific requirements of regional conservation plans in California, the approach should be applicable to monitoring design for other programs. It integrates monitoring of specific priority species with monitoring ecological integrity and incorporates an adaptive management approach. Design and creation of a monitoring program is a nine-step process:

1. Identify the conservation goals and objectives.
2. Identify the scope of the monitoring program.
3. Compile information relevant to monitoring program design.
4. Strategically divide the system and prioritize for monitoring program development.
5. Develop simple management-oriented conceptual models.
6. Identify monitoring recommendations and critical uncertainties.
7. Determine strategy for implementing monitoring.
8. Develop data quality assurance, data management, analysis, and reporting strategies.
9. Complete the adaptive management loop by ensuring effective feedback to decision-making.

In practical application, the steps in this process may overlap. At each step, it is likely that information or insights will surface that can inform and improve the products of earlier steps.

The program should clearly document its decisions and seek input and review from scientists, managers, and stakeholders throughout the process. Developing high-quality monitoring programs requires creativity as well as sufficient information on which to build a sound foundation. To keep the process as transparent as possible and for future reference, detailed records should be kept of important decisions and the rationale behind them. Because science benefits from peer review and an open and unbiased process, review should be sought early and regularly and should include some scientists completely independent of the local program.

1. Identify the conservation goals and objectives

To evaluate the success of any conservation program, clearly stated goals and objectives are essential. For every element the monitoring program needs to evaluate, there should be a specific stated goal and/or objective. The goals and objectives should ideally be:

- Easily understandable
- Biologically meaningful
- Measurable
- Feasible, both financially and scientifically
- Written with a level of detail consistent with level of current knowledge
- Compatible with goals and objectives for all covered species and habitats
- Compatible with goals and objectives for neighboring conservation lands (e.g., conservation plan reserve networks, state parks, ecological reserves)

Specific goals and objectives make the design and implementation of the monitoring program easier. Vague goals and objectives consume staff time, because monitoring program designers have to interpret the initial intention.

2. Identify the scope of the monitoring program

This step identifies the scope and boundaries of what the monitoring program intends to evaluate and identifies any requirements, constraints, and opportunities that should be accommodated in the program's design. Identification of the following elements of scope will facilitate the program design in subsequent steps:

- Geographic scope
- Land ownership and constraints
- Audiences/users of monitoring program information
- Spatial scales of focus
- Relevant time scales—biological and programmatic
- Available resources and opportunities

3. Compile information relevant to monitoring program design

Monitoring program designers should assemble information for developing conceptual models (see Step 5), information on existing monitoring programs, and existing data on species, habitats, and other environmental factors. Relevant information may come from a wide variety of sources. Note potential biases and limitations when evaluating the usefulness of information sources.

4. Strategically divide the system and set priorities

Designing effective monitoring and adaptive management programs requires a clear strategy for identifying the most important system elements to monitor and the critical uncertainties to address. This strategy should realistically meet the need for tracking individual species and other smaller scale elements while taking a systems approach, as is increasingly recommended by scientists (e.g., Ives and Cardinale 2004).

5. Develop simple management-oriented conceptual models

Once the vast array of plan components has been organized into a smaller number of species groups, natural community assemblages, and landscape-level issues, the next step is conceptual model development. Monitoring and adaptive management program design are significantly improved by use of conceptual models (National Research Council 1990; Margoluis, et al. 1998; CALFED Bay-Delta Program 2000a, 2000b; Elzinga, et al. 2001; Stevens and Gold 2003; Noon 2003; Ogden, et al. 2003; RECOVER 2004).

There are many different types of conceptual models in use. See full discussion of conceptual models in "Designing monitoring programs in an adaptive management context for regional multiple species conservation plans" (Atkinson, A.J., et al. 2004).

6. Determine what to monitor, and identify critical uncertainties

Once draft conceptual models have been assembled, the program can select which attributes of the system to monitor, determine the specific monitoring objectives and appropriate monitoring variables for each attribute, and identify critical uncertainties requiring targeted study. The program should also assess the suite of monitoring and research opportunities from a program-wide viewpoint, identifying any remaining gaps and eliminating unnecessary redundancies. Although outside review of the conceptual models is helpful, the program need not wait to receive such review before moving forward with Step 6 (see Tables 1–4 regarding monitoring variables).

7. Develop a strategy for implementing monitoring

Once the monitoring variables and critical uncertainties have been identified, they should be prioritized and organized into a workplan that includes anticipated monitoring and adaptive management tasks and timelines. The workplan should include:

- Good monitoring protocols
- Prioritized monitoring and research questions
- Monitoring and research categorized by the level of effort required
- A plan for coordination with existing monitoring programs

8. Develop data quality assurance and data management, analysis, and reporting strategies

A new monitoring program must not underestimate the importance and cost of data handling, analysis, and reporting. Monitoring information is "wasted if it is not analyzed correctly, archived well, reported in a timely manner, or communicated appropriately" (Gibbs et al. 1999). The program should invest in a good data management program. The National Park Service Inventory and Monitoring Program recommends that at least 30 percent of monitoring funds go to data management and reporting (National Park Service Inventory and Monitoring Program 2004).

Good data management maximizes the utility of the data, making it available for queries by managers and scientists addressing new issues and research questions while also providing information for the long-term monitoring program. Data generated by monitoring programs has vast potential value beyond its initial intended uses. Maintaining access to raw data, coupled with metadata describing data collection methods, greatly increases data value and utility.

A well-designed data management system also improves the level of quality assurance in the program and provides strong incentives to all program participants to standardize and coordinate protocols. The state of California is developing a multitaxa, multilevel integrated data management system for monitoring data collected throughout the state that will allow powerful queries by species, study type, habitat, or geography.

9. Complete the adaptive management loop by ensuring effective feedback to decision-making

An efficient decision support system that feeds information efficiently back into decision-making requires both initial planning and adjustment over time. Ensuring that the monitoring results appropriately influence management requires consistent effort from assigned staff who have adequate funding and a consistent attitude of getting quality information out to be evaluated, peer-reviewed, and into the hands of decision-makers in a timely fashion. Such a decision support system serves the entire conservation program.

Table 5.1: Characteristics of Good Monitoring Variables

(Adapted from Margoluis et al. 1998; Gibbs et al. 1999; Pawley 2000; Bisbal 2001; Carolyn Marn, pers. comm.).

Relevant to management
Relevant to program goals and objectives; can assess program performance Relevant to adaptive management process Appropriate spatial scale Appropriate temporal scale
Scientifically defensible
Biologically pertinent; reflects status and dynamics of system under management Sufficient scientific basis, supported by published scientific findings or conceptual models
Statistically powerful and interpretable
Directly related to the ecosystem component it is intended to represent or is an acceptable surrogate Sensitive to changes in the ecosystem component it represents Indicates cause of change as well as existence of change Timely; relevant to management timeframe Anticipatory; serves as an early warning of change Responsive across necessary range of stress; i.e., provides continuous assessment over wide range of stress (does not level off) or complements other monitoring variables to achieve necessary range Known statistical properties, with baseline data, reference, or benchmark available
Measurable and feasible
Technically feasible; measurable using standard methodologies Accurate and precise, with low observer variability and bias Cost effective Low impact to system being monitored Low risk to field personnel
Coordinated with existing programs and data sets
Compatible with already existing monitoring programs' data collection or could be modified to be so If data exist, they are obtainable, preferably as long-term data sets
Easily understood
Simple, direct Communicable; easily interpreted and explained Documented; methodology supported by complete standard operating procedures

Table 5.2. Species-level monitoring variables. Variables are listed in order of increasing level of investment and data resolution.

(Adapted from Sierra Nevada Framework (USFS 2001))

Presence in study area
Some species may be hypothesized to have been extirpated from part or all of a study area. The first priority for these species will be detection.
Habitat as surrogate
Depending on the priority level of a species and the expected pressures, habitat extent, distribution, and condition may be used as a surrogate for monitoring the species directly. However, a great deal of uncertainty exists in doing so, and the assumptions involved should be clearly documented and reassessed periodically. Typically there are insufficient data to allow confident monitoring of populations via habitat.
Number of populations
Number and location of populations can be a useful metric for rare plants and animals, especially when the coefficient of variation in the number of individuals per population is very high.
Distribution (range)
Distribution data consist of changes in locations of species occurrence across a region. Changes can occur around edges of species range, in association with pressures, or with appearance or disappearance of populations. Boundary mapping is sometimes used to measure change.
Occupancy
Target value is typically the proportion of sampling units occupied by the species. A species may maintain the same distribution, while the proportion of occupied habitat changes. When the detection probability of a protocol is less than one, better estimates are achieved using proportion of area occupied (PAO) statistics that use repeat visits to estimate the detection probability.
Relative abundance
Relative abundance is an index of abundance derived using a specific protocol. Catch per unit effort, timed surveys, timed bird point counts, and transect surveys are all different indices of relative abundance. Results derived using different protocols are not directly comparable.
Population size or absolute abundance
Population size is a direct estimate of the number of individuals. For very rare species, an absolute count (census) of the population size is possible. Where a complete census is not possible, methods such as mark/recapture and line-distance sampling provide estimates of absolute abundance.
Apparent recruitment
A qualitative or semi-quantitative measure of key stage classes for species, often including an assessment of the proportion of the population appearing to be composed of juveniles (USFS 2001).
Reproductive success
Reproductive success can be measured a variety of ways, depending on the species and sampling method. Reproductive success is most often pursued for bird species, where the number of eggs and fledglings can be readily enumerated to calculate number of young produced per adult. It is also described for some taxa in terms of the proportion of females reproducing. However, an index of the number of young produced per adult or breeding pair can be derived for most species (USFS 2001).

Table 5.2. Species-level monitoring variables, cont.

Population structure and dynamics
Many measures of population growth and structure are available for use in monitoring. They range from individual attributes of a population (e.g., age ratios, sex ratio) to derived rates of change (e.g., mortality rates, fecundity rates, growth rates) (USFS 2001) to population genetic structure.
Population condition (in association with other monitoring)
A sample of individuals is captured or otherwise inspected and their condition determined relative to issues (e.g., tissue contamination index, parasite loads, symptoms of disease). The proportion showing signs of impaired condition is then used to monitor population condition.

Table 5.3, below, shows examples of the types of monitoring variables often suggested as indicators of natural community assemblage condition. Such examples are for illustration purposes only and are not what would necessarily be chosen to monitor for a specific program. Programs should not skip the steps of model development and identifying testable questions. Some monitoring variables require research, such as identifying which species are "stress-sensitive species" vs. "stress-tolerant species." In general, before adopting any indicator, field verification and fine-tuning in the system of interest is required. Definitions are not provided for each suggested measure, but key references have been cited where possible.

Table 5.3: Natural community assemblage monitoring variables

Community composition variables

Where protection of biological diversity is a goal, community-level monitoring is needed to evaluate success. This topic has been addressed in detail in the scientific literature, but ultimately the approach taken will depend on the goals of the conservation program.

- Native species richness—estimate of the number of species in an area (Krebs 1999).
- Measures of similarity and association based on species presence or abundance can be used to compare community composition with a baseline condition or reference site (Krebs 1999; Morrison et al. 2001).
- Presence, abundance, biomass, capture rate, or proportional capture rate of
  - ◊ guilds or functional groups (e.g., in songbirds: ground gleaners, foliage gleaners, aerial hawkers; in planktonic communities: phytoplankton, microzooplankton, mesozooplankton).
  - ◊ key species; e.g., focal species (keystone, umbrella, and/or engineer species (Noon 2003)), at-risk species (legally protected species and otherwise sensitive species (Noon 2003)), community indicator species, habitat indicator species, economic species, pest species (Goals Project 1999).
  - ◊ stress-sensitive versus tolerant species; e.g., species that do poorly in urban environments versus those that adapt well
  - ◊ native versus non-native species.
- Index of Biotic Integrity (IBI): Using reference systems of known condition or integrity, a diversity-based index of biotic integrity is developed. This IBI can then be used to assess the condition of other systems based on a diversity-based score (Noss et al. 1997; National Research Council 2000).

Table 5.3: Natural community assemblage monitoring variables, cont.

Vegetation structure and function variables
In many systems, wildlife and plants of interest are critically dependent on local vegetation structure. Monitoring vegetation may provide early indication of changes that are known or hypothesized to be detrimental; e.g., weeds or community succession. • Estimation of absolute and relative abundance (or cover) of native and non-native species using standard vegetation survey methods. This is the most time- and labor-intensive approach to vegetation monitoring. • Shrubland vegetation structure metrics (percent cover, canopy height, percent shrub cover, percent tree cover, percent grass and forb cover, percent of specific vegetation series species, patchiness of vegetation cover, soil type, litter depth). • Forest vegetation structure metrics: frequency distribution of seral stages (age classes) for each community type and across all types; woody stem density in various size (dbh) classes; average, range and diversity of tree ages or sizes in stand; tree species diversity; productivity; canopy density and size and dispersion of canopy openings; foliage-height profiles; abundance and density of key structural features (e.g., snags and downed logs); crown condition; physical damage to trees (Noss et al. 1997; National Research Council 2000). • Photo plots: Photos taken from fixed reference points can provide a qualitative and sometimes a quantitative assessment of changes in the environment (MacDonald and Smart, 1992). Photos should be recorded at the same time of year, in the same direction, etc.
Ecological function
Although conceptually attractive, monitoring general ecological function is rare unless there is an obvious connection to issues of value to humans. Terrestrial • Energetics/productivity—biomass, carbon storage, net primary production, productivity (National Research Council 2000). Productivity is more clearly of interest in extraction systems such as working forests. • Fires and other disturbances—frequency, return interval or rotation period of fires or other disturbances, location and areal extent, will influence the diversity, abundance and distribution of vegetative communities and associated wildlife (Noss et al. 1997). • Soil stability and erosive resistance, slumping—early successional species may require landslides. • Weather (precipitation, high-low-average temperature, humidity, evapotranspiration index). Aquatic • Streams/rivers—stream flow and stage (height), stream flow hydrographs, frequency and extent of floodplain inundation • Channel migration, bank and channel stability and erosive resistance, stream cross-sectional area • Water quality—water clarity/turbidity, conductivity, temperature, pH, dissolved oxygen, organic carbon, nutrients, contaminants • Biological oxygen demand (BOD) • Sediment quality—composition and grain size, total organic carbon, nitrogen, sulfides, pH, contaminants

In Table 5.4, below, examples are provided of variables that might be used to monitor landscape-level issues that affect multiple natural community assemblages or otherwise cross-cutting issues. Such examples are for illustration purposes only and are not what would necessarily be chosen to monitor for a specific program. Programs should not skip the steps of model development and identifying testable questions.

Table 5.4. Landscape-level monitoring variables

Extent and distribution of habitats across landscape

- Extent, distribution and location of protected lands and land uses (natural, agricultural, disturbed, urban, military, etc.).
- Extent and distribution of natural communities and natural community assemblages.
- Extent of core habitat (e.g., >500 m from roads or development), because many species of concern do not survive or reproduce well when subject to disturbance or other edge effects (Noss et al. 1997; Rutledge 2003).

Fragmentation, connectivity, measures of patch characteristics and dispersion

- Patch characteristics and dispersion measures—interpatch distance (mean, median, range) for various natural community assemblages; patch density; number of patches; patch size frequency distribution; nearest neighbor (Noss et al. 1997; Rutledge 2003).
- Road density inside reserves and in total planning area (Noss et al. 1997).
- Studies to assess animal movement across barriers or through hypothesized corridors. Use radio tracking or marked animals, or possibly develop genetic markers to assess gene flow indirectly.

Invasive species

- Range, rate of spread, distribution, and size of populations of key nonindigenous plant species (e.g., *Arundo donax*, *Tamarisk* spp., perennial pepperweed, purple loosestrife, water hyacinth, ice-plant, yellow starthistle, pampas grass, non-native annual grasses) and non-native fauna (e.g. fire ants, Argentine ants, bullfrogs, African clawed frogs, crayfish, non-native fish, non-native foxes, non-native turtles, feral cats and dogs).
- Detection of new species at common introduction points (e.g., plant nurseries for fire ants, trails for yellow starthistle, international shipyards for aquatic organisms in estuaries).
- Maintain information clearinghouse to report new invasive species established in region and provide information on invasive species status, ecology, and control methods.

Large-scale or widely distributed pressures

- Fires and other disturbances—frequency, return interval, or rotation period of fires or other disturbances, location, and areal extent (Noss et al. 1997).
- Location and severity of potential pressures on system (e.g., dams and impoundments, water diversions, sources and distribution of contaminants).
- Intensity of human recreation use or other land uses (e.g., livestock stocking rates).

Current Monitoring Efforts

Numerous existing programs of Fish and Game and other agencies, conservation organizations, and research institutions are monitoring wildlife resources across the state in terrestrial, aquatic, and marine environments. These programs monitor at the regional, natural community, ecosystem function, and species levels. In 2005, the Fish and Game Resource Assessment Program, as part of the development of this plan, conducted an initial survey of wildlife monitoring projects and programs throughout the state. The survey was designed to provide a summary of current wildlife monitoring efforts in California and to facilitate communication among different individuals, organizations, and agencies. More than 400 monitoring efforts were identified, and basic information including location, project purpose, and lead organization were categorized into a comprehensive Wildlife Monitoring Survey. Survey results may be viewed and queried on the California Wildlife Action Plan Web site at http://www.dfg.ca.gov/habitats/wdp/project_search.asp.

Geographically the third-largest state in the nation, California is also the most biodiverse. Given its extensive area, the diversity of species, and the numbers of special-status species, the job of monitoring and assessing California's native wildlife statewide is enormous. There are scores of biologists associated with various public and private institutions studying wildlife and wildlife issues.

Surveying wildlife assessment work across the state involves contacting hundreds of researchers and institutions. For this survey, attempts were made to contact biologists at 20 federal, state, and local agencies or branches, including the U.S. Department of the Interior, the U.S. Department of Agriculture, the U.S. Department of Defense, the California Department of Fish and Game, State Parks, Department of Forestry and Fire Protection, Department of Water Resources, and Bay-Delta Authority.

There are 10 campuses within the University of California system, 21 campuses within the California State University system, 25 private colleges and universities, and 103 community colleges that have biological science departments and natural reserves with faculty who may be actively engaged in wildlife research. In addition, there are numerous local biologists employed by city and county governments, nonprofit groups and foundations, and private consulting firms who may be actively involved in wildlife research or may coordinate wildlife monitoring programs. Since research or monitoring projects that actually involve handling wild animals must have a permit (more than 2,700 scientific collecting permits to individuals from more than 800 different organizations were issued in 2004 by Fish and Game's License and Revenue Branch), they provided a source of information to identify monitoring programs statewide. This initial survey identified only a portion of the wildlife monitoring and resource assessment activities in California.

Examples of the current monitoring programs in California at the regional, natural community, ecosystem function, and species levels are described below.

Examples of Regional Level Monitoring

Western Riverside County MSHCP Biological Monitoring Program

(Resource Assessment Program, Fish and Game)

In 2003, the Department began developing a long-term monitoring program to determine the status and trend of 146 sensitive plant and animal species within the western Riverside County MSHCP conservation area. The goal of the monitoring program is to implement a multiple species approach that 1) targets the 146 covered species and associated plant and animal communities, 2) provides data on whether the biological objectives of the MSHCP are being met, and 3) provides data to the adaptive management program. The monitoring program is implemented in two phases. The inventory phase, carried out during the first five years of the permit, focuses on mapping vegetation communities, gathering and synthesizing existing species information, conducting field surveys for selected species, and testing a community-based approach. The long-term monitoring phase will employ a multiple species sampling strategy that is developed based on the information gathered during the inventory phase. The Department is leading the first five- to eight-year inventory phase that will be followed by long-term monitoring.

See http://www.dfg.ca.gov/habitats/RAP/project_summaries_expand_all.html

Coastal Watershed Assessments Planning and Assessment Program

The Coastal Watershed Planning and Assessment Program (CWPAP) is a Fish and Game program conducting fishery-based watershed assessments along the length of the California coast. Assessment basins are chosen as study areas based upon the nature of the socio-economic and natural resource problems within them. The Fish and Game Coho Recovery Plan and Steelhead Recovery Plan are useful in selecting basins, as well. CWPAP has developed assessment methods, protocols, and report outlines. The program's work is intended to provide answers to the following six guiding assessment questions at the basin, subbasin, and tributary scales in coastal watersheds:

- What are the history and trends of the size, distribution, and relative health and diversity of salmonid populations?
- What are the current salmonid habitat conditions; how do these conditions compare to desired conditions?
- What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?
- How has land use affected these natural processes and conditions?
- Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What watershed management and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost-effective manner?

One of the products of the CWPAP is to determine monitoring needs to support adaptive management.

Bay-Delta Interagency Ecological Program

The Interagency Ecological Program's monitoring element encompasses both biological and physical parameters. It does so by utilizing the combined resources and expertise of the various member agencies to provide a clearer understanding of the many factors that affect the health of the San Francisco Bay/Estuary ecosystem. Results from the monitoring program may be found at www.delta.dfg.ca.gov or at the IEP database (www.iep.ca.gov). Components of the monitoring program include:

- Fall Midwater Trawl—Annual survey to determine the abundance and distribution of juvenile and early-adult pelagic fishes in the San Francisco Estuary and lower Sacramento and San Joaquin rivers.
- Summer Townet Survey—Annual survey to determine the abundance and distribution of late-stage larvae and juvenile pelagic fishes in the San Francisco Estuary and lower Sacramento and San Joaquin rivers.
- 20 mm Survey—Annual survey to determine the abundance and distribution of late-stage larvae and early juvenile pelagic fishes in the San Francisco Estuary and lower Sacramento and San Joaquin rivers. Data are reported on a near real-time basis (within one day of collection) and are used to guide State Water Project and Central Valley Project operation decisions during the spring.
- Larval Fish Survey—Annual survey to determine the abundance and distribution of late-stage larvae and early juvenile pelagic fishes in the San Francisco Estuary and lower Sacramento and San Joaquin rivers.
- Spring Kodiak Trawl—Long-term survey of small adult pelagic fishes, principally delta and longfin smelt, in the San Francisco Estuary and lower Sacramento and San Joaquin rivers.

- Delta Outflow/San Francisco Study—Survey of juvenile and early-adult pelagic fishes, shrimp, and crabs in the San Francisco Estuary and lower Sacramento and San Joaquin rivers.
- Delta Resident Fishes Survey—Electrofishing survey of inshore and near-shore fishes in the upper San Francisco Estuary and lower Sacramento and San Joaquin rivers.
- Adult Striped Bass Population Estimates—Gill-net and **fyke**-net-based mark and recapture effort for striped bass (>18 inches) in the lower Sacramento and San Joaquin rivers. All tagged fish are aged from scales. Information from associated creel census is used to estimate harvest rate, mortality rates, and population estimates for all age groups.
- Adult Sturgeon Population Estimates—Trammel-net-based mark-and-recapture effort for adult white sturgeon that takes place in September and October. Typically, tagging has been done two out of every five years. Currently, it is now being done annually and the time expanded to start in August to facilitate the tagging of green sturgeon. Adult sturgeon are collected using boat-deployed trammel nets in San Pablo and Suisun bays. Information is used to estimate harvest rate, mortality rates, and population estimates for all age groups.
- Ecosystem Monitoring Program (EMP)—This program provides necessary information for compliance with flow-related water quality standards. The EMP also provides information on a wide range of chemical, physical, and biological baseline variables. Discrete water quality stations are sampled monthly using a research vessel and a laboratory van. Several constituents are also measured continuously at eight stations. In addition, the EMP collects and analyzes benthos, phytoplankton, and zooplankton samples.
- CVP and SWP Fish Salvage Reporting—Survey of fish collected at the State Water Project Skinner Fish Facility and the Central Valley Project Tracy facility. Fish are collected as part of the diversion of water from the estuary to CVP and SWP customers. See www.delta.dfg.ca.gov and www.iep.ca.gov

Examples of Natural Community Level Monitoring

Montane Meadow Monitoring Program

(Resource Assessment Program, Fish and Game)

In 2001, Fish and Game initiated a community approach to assessing montane meadows in the Sierra Nevada, recognizing the importance of such communities to many wildlife species of concern. In part, recognition of the importance of these systems through the U.S. Forest Service's Sierra Nevada Framework and the congressionally mandated Sierra Nevada Ecosystem Project spurred the initiation of this three-phase program. The first phase has been to develop a high-resolution map product of the distribution of montane meadows in the Sierra Nevada. Specific umbrella wildlife species, such as the willow flycatcher and great gray owl, where population status and dynamics reflect the condition and quality of montane meadow systems, are also being surveyed as potential indicator or umbrella species in anticipation of a long-term monitoring strategy. Numerous other wildlife species are also being surveyed in these communities using remote camera stations, visual encounter surveys, focal point counts, and trapping. Because of their typical close association as habitats, the program also is working to map and identify the condition of quaking aspen communities in a collaborative effort with the U.S. Forest Service and Bureau of Land Management.

See http://www.dfg.ca.gov/habitats/RAP/project_summaries_expand_all.html

Landscape Habitat and Wildlife Monitoring Program
(Department of Fish and Game, Region 1)

This program monitors habitats and wildlife at plots throughout the Klamath, Southern Cascades, and Modoc ecoregions. The objective is to describe baseline conditions and assess trends with respect to habitat conditions and wildlife populations at the landscape scale. Information gathered from this monitoring project is used to inform management decisions. To date, 335 plots have been monitored over four years. Through various methods, including breeding bird surveys, small mammal trapping, and baited camera stations, more than 160 species of birds and mammals have been identified at these plots.

Channel Islands Marine Protected Areas Monitoring

The Channel Island Marine Protected Areas (CIMPA) monitoring plan (CDFG 2004) includes both biological and socioeconomic components. Data are collected both inside the MPA and in adjacent areas outside the MPA to detect differences in the indicator parameters. The plan cites values from the literature concerning expected changes in density and size for a variety of species.

The CIMPA monitoring plan objectives are to determine:

- Changes in abundance, size, biomass, and spawning biomass of species
- Species composition as it relates to ecosystem function
- Habitat changes as they relate to physical alteration (e.g., trawling) and secondary impacts of biological community changes (e.g., habitat-forming algae)
- Amount of spillover
- Changes in catch per unit effort and total catch

Biological monitoring activities have been separated into four general habitat/ecosystem categories: shallow subtidal; deep subtidal; intertidal; and seabirds and marine mammals. The monitoring categories have been prioritized based on the expected level of impact that marine protected areas will have on the species or habitats, the need for new monitoring activities, the feasibility of determining changes, and the relative level of previous consumptive use.

See http://www.dfg.ca.gov/mrd/channel_islands/monitoring.html

Examples of Ecosystem Function Level Monitoring

Multi-Agency Fish Barrier Monitoring and Fish Passage Assessment

In recognition of the importance of California's once-abundant salmon and steelhead populations, the State Coastal Conservancy, in collaboration with the California Department of Fish and Game and the Pacific States Marine Fisheries Commission, have initiated an inventory of existing barriers to fish passage throughout the state. The inventory is to be used to identify barriers suitable for removal or modification to restore habitat connectivity, spawning, and riparian conditions for salmon and steelhead and to enhance aquatic and riparian habitat.

The Passage Assessment Database (PAD) is an ongoing map-based inventory of known and potential barriers to anadromous fish in California, compiled and maintained through a cooperative interagency agreement. The PAD compiles currently available fish passage information from many different sources, allows past and future barrier assessments to be standardized and stored in one place, and enables the analysis of cumulative effects of passage barriers in the context of overall watershed health. The database is set up to capture basic information about each potential barrier. It is designed to be flexible. As the database grows, other modules may be added to increase data detail and complexity.

See http://www.calfish.org/DesktopDefault.aspx?tabId=69

Meadow Status and Trend Monitoring

(Pacific Southwest Research Station, USFS)

The focus of the meadow monitoring program was to determine the ecological condition of montane meadows within the Sierra Nevada Forest Plan Amendment study area. The study surveyed a random selection of herbaceous meadows. The program arose out of concerns raised in the Sierra Nevada Ecosystem Project Final Report about the ecological condition of aquatic, riparian, and meadow ecosystems. Meadows in the sample area are distributed across a broad range of elevations and include remote meadows that are seldom visited as well as meadows with recreation and grazing activities and roads. Data collection included plant species composition, nested rooted frequency, ground cover, and soil hydrologic characteristics in a more holistic approach to ecosystem functioning than has been done in past studies.

See http://www.fs.fed.us/psw/topics/wildlife/

Monitoring the Responses of Sensitive Herpetofauna to Manipulated Flow Regimes and Salmonid-focused Habitat Modifications Along the Mainstem Trinity River
(Pacific Southwest Research Station, USFS)

The western pond turtle and foothill yellow-legged frog have been impacted by the construction and operation of dams on the mainstem of the Trinity River. Responses of these sensitive herpetofauna to manipulated flow regimes and salmonid-focused habitat modifications are monitored and management recommendations are offered based on monitoring findings.

See http://www.fs.fed.us/psw/

Examples of Species Level Monitoring

Statewide Swainson's Hawk Survey/Monitoring Program and Study of Crop/Habitat Foraging Value
(Resource Assessment Program, Fish and Game)

Based on two years (2005 and 2006) of intensive statewide surveying to establish a baseline, the intent of this program is to institute an objective statewide monitoring program and implement key applied research studies to enhance our understanding of the Swainson's hawk and its habitat relationships. A long-term monitoring strategy will be designed after the 2006 field season to objectively monitor and track Swainson's hawk population at a large regional (Central Valley) scale. The purpose of the five-year study program on crop/habitat value is to develop more accurate models of the relationship between Swainson's hawk use of agricultural crops and native habitats and to specifically develop a foraging value for the various land-cover types. This information can then be used for conservation, management, and planning efforts to benefit the species to the extent possible.

See http://www.dfg.ca.gov/habitats/RAP/project_summaries_expand_all.html

Marbled Murrelet Research Projects
(Pacific Southwest Research Station, USFS)

One of the primary goals of the USFS Pacific Southwest Research Station's bird monitoring research has been to conduct research on habitat relationships of birds associated with forest ecosystems. The station began its research on the marbled murrelet in 1987, after the USGS identified the species in old-growth forests where it was conducting research on other forest birds. This seabird has the unique strategy of utilizing both the marine and terrestrial environments by foraging at sea and nesting in the old-growth forests. Over the past 100 years, the murrelet population has been in decline and, in 1992, was listed as threatened under the federal Endangered Species Act. The Research Station's research has provided valuable information for the Marbled Murrelet Recovery Team on the species status and habitat requirements. The Research Station also has provided research and expertise to the Northwest Forest Plan since 1992 to inform resource management decisions.

See http://www.fs.fed.us/psw/topics/wildlife/birdmon/mamu/

Aquatic Amphibian and Reptile Surveys
(Bureau of Land Management)

Aquatic amphibians are good indicators of the health of aquatic systems (Hall 1980). Through monitoring the trends in the abundance of foothill yellow-legged frogs, BLM is able to make management decisions that provide for high-quality, low-impact OHV recreation and travel while conserving frog populations. BLM staff at the Hollister Field Office developed a monitoring protocol for the foothill yellow-legged frogs in 2001. Surveys for yellow-legged frogs occur inside 10 100-meter-long by 1-meter wide transects at OHV crossings and 10 identically shaped transects away from OHV crossings. BLM samples streams in accordance with a standardized protocol for surveying aquatic amphibians (Fellers and Freel, 1995). The project surveys creeks in the Hollister area that potentially support populations of foothill yellow-legged frog, western pond turtle and two-striped garter snake. Annual monitoring is conducted at a subset of transect sites.

Marine Invasive Species Monitoring Program
(Office of Spill Prevention and Response, Fish and Game)

The Ballast Water Management Act of 1999 established a multi-agency program to prevent the introduction and spread of non-indigenous aquatic species (NAS) from the ballast of ships into the state waters of California. This program was designed to control ballast introductions and determine the current level of species invasions while researching alternatives to the present control strategies. Under this program, Fish and Game was required to study the extent of non-native species introductions into the coastal waters of the state. To fulfill this requirement, the Department's Office of Spill Prevention and Response (OSPR) initiated several baseline field surveys of ports and bays along the California coast and a literature survey of records of non-indigenous species (NIS).

OSPR's first survey (in 2000) targeted California's seven major harbor areas from Humboldt Bay to San Diego Harbor, and most of the smaller ports and bays along the entire coast, from Crescent City, near the Oregon border, to Mission Bay in San Diego. The survey and literature searches revealed that all areas of the California coast have experienced some level of invasion by species not native to California. Researchers have found a total of 397 non-native organisms in California's marine, estuarine, and tidal freshwater environments. An additional 339 organisms were classified as "cryptogenic," meaning that it was not obvious whether they were native or introduced but were likely introduced, as they have not been identified previously.

See http://www.dfg.ca.gov/ospr/organizational/scientific/exotic/MISMP.htm

Monitoring Effectiveness of Conservation Actions

While current regional, natural community, ecosystem function, and species monitoring efforts are adequate to assess the progress of some of the recommended conservation actions, in most cases, additional monitoring efforts are needed.

The lead agency, organization, or collaborative partners implementing a conservation action should review what information and monitoring are required to assess progress and to support adaptive management. Answering the five questions below will help design the effectiveness assessment for a conservation action.

1. What questions need to be answered to assess effectiveness or progress of the conservation action?

See Assessment Questions for each conservation action in Appendix J. The lead agency or collaborators should review these questions and reach agreement on a complete list of those that are relevant.

2. What is the monitoring level and what are the information or monitoring requirements needed to answer the assessment questions?

The level of monitoring needed depends on the nature of the goals and objectives of the conservation action. If the goal is to recover one species, then monitoring that species may be all that is required. However, if the goal is to restore natural communities over a large landscape, such as sagebrush communities on the Modoc Plateau, monitoring will be at a more comprehensive level. Monitoring levels are identified for each conservation action in Appendix J (see Table 5.5, Monitoring Levels). The lead agency or collaborators should design a monitoring program to gather the information required to assess success of the conservation action. Regional, natural community, ecosystem function, or otherwise complex monitoring programs should be based on a thorough review of the monitoring and adaptive management needs based on a process such as the guidance offered in Section 1. Then, the monitoring requirements should be listed.

3. What current monitoring programs provide information that helps to answer the assessment questions?

As described in the previous section, there are hundreds of wildlife monitoring efforts in California. Current relevant monitoring programs may be identified by:

- Searching the Wildlife Monitoring Survey at http://www.dfg.ca.gov/habitats/wdp/project_search.asp. The monitoring programs may be searched by region, project purpose, and lead organization.
- Contacting the monitoring and research units of the potential collaborators listed in Appendix J. Many of the listed collaborator's Web sites have links to other organizations conducting research or monitoring in their region.
- Reviewing the current literature regarding relevant species and natural systems.

4. What additional monitoring efforts are needed to answer the assessment questions?

Compare identified monitoring requirements with current monitoring efforts to determine the need for additional monitoring.

5. What organizations or collaborators are appropriate to implement the additional monitoring requirements?

An initial list of potential collaborators is given with each conservation action in Appendix J. This list is only a starting point. By reviewing the Web links provided on the Web sites of the potential collaborators, other collaborators may be found, including non-governmental conservation organizations, university science centers, and local conservation programs.

Monitoring Level

The conservation actions recommended in this plan vary in management level, geographic scale, and complexity. Some may be implemented through regional multi-agency collaborative efforts, while others may be implemented by a single program within a state department. Some conservation actions are focused on a small geographical area, while others apply to a large region of the state, if not the entire state. Some conservation actions affect a specific environmental characteristic, whereas other actions relate to the dynamics of natural communities.

Assessing the effectiveness of a conservation action requires matching the level of monitoring to the nature of the conservation action. Some actions warrant monitoring at multiple levels. Monitoring levels relevant to the recommended conservation actions are identified in Appendix J. The monitoring levels range from management level to species level, as defined in Table 5.5.

Table 5.5: Monitoring Levels

Management
Involves a management or budget action to ultimately benefit conservation programs and projects. For example, among the conservation actions is a recommendation to strengthen the state's capacity to assist local governments with conservation planning and implementation.
Regional
Involves monitoring the full complexity of a geographical area that may encompass several watersheds, numerous natural communities, a diversity of species populations and ecological systems. The Wildlife Action Plan divided the state into nine large regions for analysis. However, regional-level assessment may apply to geographically smaller areas, such as the areas within a Natural Community Conservation Plan in Southern California.
Natural Community
Involves monitoring the community of native plants and animals, many of which are interdependent, in a given ecosystem. Often named for the principal type of vegetation in the community; for example, "coastal sage scrub community" or "blue oak woodland community."
Ecosystem Function
Involves monitoring the operational role of ecosystem components, structure, and processes.
Habitat Linkages
Involves monitoring pathways of natural habitat occurring within larger developed areas or converted lands. The habitat linkage areas attract wildlife and act as safe passages for wildlife between neighboring natural areas. Linkages are often along creek riparian zones that run through cropped fields or urban areas.
Species
Involves monitoring species, populations of species, or groups of species. Species are often monitored as part of recovery programs and as one of numerous "covered species" of a habitat conservation plan.

Collaborative Monitoring Efforts

Collaborative monitoring programs involving multiple agencies, nongovernmental organizations, landowners, or university researchers have several benefits. Multiple collaborators are collectively more likely to have knowledge of all current monitoring programs. The broader expertise and perspectives of collaborators will contribute to design of monitoring programs that yield better information. In addition, through the collaborative process, monitoring protocols will be more compatible and the monitoring results are likely to be more broadly disseminated for informing conservation decisions. Collaborative efforts with farmers and ranchers are important to monitor wildlife resources on private lands, which constitute about half the state. The Wildlife Action Plan encourages collaborative efforts to implement most of the recommended conservation actions.